TECHNICAL NOTES

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April 22, 1980

RE: Broom Snakeweed: Effect on shortgrass Forage Production and Soil Water Depletion

by Darrell N. Ueckert
reprint from Journal of Range Management

This technical note transmits basic references and ecological data on broom snakeweed.

Please file and cross-reference to poisonous plants and plant communities.

Prepared by:
Donell D. Sylvester
Range Conservationist
Soil Conservation Service
Albuquerque, NM

Attachment

AC - 1 each
DC - 1 each
Area Range Conservationist - 1 each

W/O attachment:
Adjoining states - CO, AZ, TX, UT, OK - 1 each
WTSC, Portland - 2
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Broom Snakeweed: Effect on Shortgrass Forage Production and Soil Water Depletion

DARRELL N. UECKERT

Abstract

Perennial shortgrasses were delayed in responding to removal of a dense broom snakeweed population ($387/m^2$) because of low initial vigor. However, after 1 year, grass production increased by 07% (1,175 kg/ha) and after 2 years, by 324% (2,201 kg/ha) compared to undisturbed stands. Reducing snakeweed density by 25 or 50% did not affect forage production during the 2-year study. Estimated carrying capacity of the shortgrass rangeland was increased from 1 A.U./26 ha to 1 A.U./6.1 ha by the second year after complete removal of broom snakeweed. Juvenile broom snakeweed plants utilized soil water from the upper 15 to 45 cm. Soil water depletion was increased after perennial grasses regained vigor following complete removal of snakeweeds. Precipitation-use efficiency for production of usable forage was 2.1 and 4.3 times greater on broom snakeweed-free rangeland than on infested rangeland at 1 and 2 years, respectively, following removal of snakeweed.

Broom snakeweed [*Xanthocephalum sarothrae* (Pursh) Shinners], also referred to as perennial broomweed, turpentineweed, and slinkweed, is common on rangelands throughout the western two-thirds of Texas and west to California, north to Canada and south into Mexico (Ragsdale 1969). Broom snakeweed, a short-lived, perennial half-shrub, often increases in abundance following heavy grazing of shortgrass rangeland (Stoddart et al. 1975). The species aggressively invades disturbed areas but its populations are cyclic and it is not a reliable indicator of overgrazing (Jameson 1970; Vallentine 1971).

Extensive areas of rangeland in the western half of Texas became heavily infested with broom snakeweed and threadleaf snakeweed [*X. microcephalum* (DC.) Shinners] after the drought of the 1950's (Ragsdale 1969). These populations have persisted, but stand densities vary with weather cycles. Both species are toxic to cattle, sheep, goats, and several other species of animals (Sperry et al. 1964). The most common problem is abortion in cattle, and this is most severe on sandy soils, where as many as 60% of the pregnant cows abort, delivering dead or small, weak calves (Sperry et al. 1964).

Control of broom snakeweed with herbicides has been erratic (Allen and Dollahite 1959). Sperry and Robison (1963) reported that amine and ester formulations of 2,4-D [(2,4-dichlorophenoxy) acetic acid] in water at 1.12 kg/ha were the most effective herbicides then available, but that optimum growing conditions at time of spraying and, in most cases, two successive treatments were necessary for control of broom snakeweed. Schmutz and Little (1970) achieved excellent control of broom snakeweed in central Arizona with 0.56 kg/ha of picloram (4-amino-3,5,6-trichloropicolinic acid) as granules applied from September through December and as folair sprays applied in April. They reported that picloram was two to four times more toxic to broom snakeweed than 2,4-D or 2,4,5-T [2,4,5-trichlorophenoxy) acetic acid]. Gesink et al. (1973) reported excellent control of broom snakeweed on shortgrass rangeland in Wyoming with June application of picloram sprayed at 0.56 kg/ha and with picloram + 2,4-D (0.28 + 1.12 kg/ha). Boyd et al. (1976) reported that fall, winter, or spring application of tebuthiuron (*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N,N*'-dimethylurea) sprayed at 0.14 to 0.28 kg/ha reduced broom snakeweed standing crop biomass by 80% on shortgrass rangeland. Dwyer (1967) reported that burning in June killed 96% of the broom snakeweed plants in a blue grama (*Bouteloua gracilis* H.B.K.) range in New Mexico, but that burns in October, January and April killed only 35, 25, and

Author was associate professor, Department of Range and Wildlife Management, Texas Tech University, when the research was initiated and associate professor, Texas A&M University Agricultural Research and Extension Center, Route 1, Box 950, San Angelo, Texas 76901, when the research was finished.

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45%, respectively. Hopkins et al. (1948) reported that burning shortgrass rangeland in western Kansas effectively controlled broom snakeweed.

Most studies on broom snakeweed have dealt with control or icity. The objectives of this study were to evaluate compe-ion between broom snakeweed and perennial grasses on shortgrass prairie rangeland and to study the effect of broom snakeweed on soil water depletion.

Methods and Materials

This study was conducted on the rangeland portion of the Texas Tech University Farm in Lubbock County. The site supported a semiarid shortgrass community dominated by honey mesquite (*Prosopis glandulosa* Torr. var. *glandulosa*), blue grama, buffalograss (*Buchloe dactyloides* Nutt.), and broom snakeweed. The mean annual precipitation is 48 cm. The soil is an Amarillo fine sandy loam (fine loamy mixed, thermic family of Aridic Paleustalfs).

The study area has been heavily grazed by cattle during 1974-75, and abundant precipitation during the fall-winter period resulted in a dense (387 seedlings/m^2), relatively homogeneous stand of broom snakeweed seedlings in the spring of 1975. On July 30 and 31, 1975, broom snakeweed plant density was reduced by 0, 25, 50, or 100% (based on original density) on 3 m by 3 m plots arranged in a randomized complete block design with three replications of each density reduction treatment. Seedlings were killed by cutting slightly below the soil surface with a sharp knife and were removed from the plots. A 1-m border around each plot was plowed with a garden tiller to minimize edge effect. All mesquite within 15 m of the plots were killed. The study area was fenced to exclude livestock and lagomorphs on August 8, 1975. A high level of feeding activity by desert termites (*Gnathamitermes tubiformans*), evidenced by an abundance of mud casts and sheetings over dead and live herbaceous vegetation, occurred the spring of 1976. Since the influence of broom snakeweed density uction treatments upon termite feeding activity was not known, it s deemed essential to eliminate termites from all experimental plots. This was accomplished by spraying all plots with chlordane (octachloro-4, 7-methanotetrahydroindane) at 3.37 kg a.i./ha in 3.8 litters of water per plot on June 21, 1976.

Density of broom snakeweed was determined immediately after mechanical thinning by counting individual plants in 0.25-m^2 quadrats. From 5 to 13 quadrats were necessary to estimate mean density on a plot adequately. Also, counting consistently underestimated actual numbers of broom snakeweed plants because of the difficulty in discerning an individual plant. Count data were corrected to actual density using regression equations obtained by counting (independent variable), then uprooting and re-counting plants (dependent variable), in 10 quadrats outside the experimental plots. Reduced densities were maintained by monitoring broom snakeweed density on August 25 and October 20, 1975, and on May 20, 1976, and thinning when necessary.

A point frame was used on October 22, 1975, to obtain cover repetition, the number of aerial hits per pin, for broom snakeweed and perennial grasses on the study plots. One hundred randomly located point samples were recorded for each plot. Cover repetition is highly correlated with aboveground biomass (Conant and Risser 1974). Standing crop biomass (oven-dry) of perennial grasses and broom snakeweed was determined on each plot by clipping vegetation to ground line in 10 randomly located 0.1-m^2 quadrats on the western half of each plot at 1 year post treatment (August 20, 1976), and in 10 randomly located 0.1-m^2 quadrats on the eastern half of each plot at 2 years post treatment (July 19, 1977). Vegetation samples were oven-dried at 60°C for 72 hr before weighing.

Soil water was determined by the gravimetric method (Gardner 5) from three, randomly located, 2.5-cm diam soil cores for each cm increment to a depth of 120 cm on each plot on October 9, 1975, January 13, 1976, April 7, 1976, and August 18, 1976 (3, 6, 9, and 13 months post treatment); and to a depth of 90 cm on July 20, 1977 (2 years post treatment). Soil bulk density values for each 15-cm increment, determined from five, 5.4-cm diam by 5.9 cm, undisturbed soil cores by the core method (Blake 1965) were used for computing volumetric soil water. Soil water at −⅓, −1 and −15 bars for the Amarillo fine sandy loam profile was calculated from data collected less that 400 m from the study area on the same soil unit (Bryant 1977). Precipitation was recorded on the study area after each precipitation event. Precipitation-use efficiency was calculated as the units (kg/ha) of herbage produced per unit (cm) of precipitation received during the preceding 12-month period.

Data on cover repetition, standing crop biomass and soil water were subjected to analysis of variance. Multiple range tests were used to separate treatment means where appropriate.

Results and Discussion

Broom Snakeweed Density and Mortality

In August 1975, the original mean population density of broom snakeweed seedlings was 387/m^2 (range 332 to 444/m^2). Similar stand densities were common throughout the Texas Panhandle and eastern New Mexico. By October 1975, the mean density was 242 seedlings/m^2 (37.5% mortality). Precipitation during the period June through September 1975 (29 cm, Fig. 1), was above average, but apparently was not adequate to support the initial high density of seedlings. Natural mortality of seedlings from August to October 1975, was 18.1% and 8.3% on plots where seedling density was reduced by 25% and 50%, respectively. Mortality from October 20, 1975, through May 20, 1976, was 24.8% on the undisturbed plots and 4.4% and 0% on plots where density was reduced by 25% and 50%, respectively. Only 9.6 cm of precipitation was received during the period October 1975 through May 1976. These data indicate that intraspecific competition within the broom snakeweed population was intense and that reducing plant density by 25% or 50% greatly reduced this competition. Density data were not recorded after May 1976, but very few dead plants and no new seedlings were present in July 1977 on any of the plots.

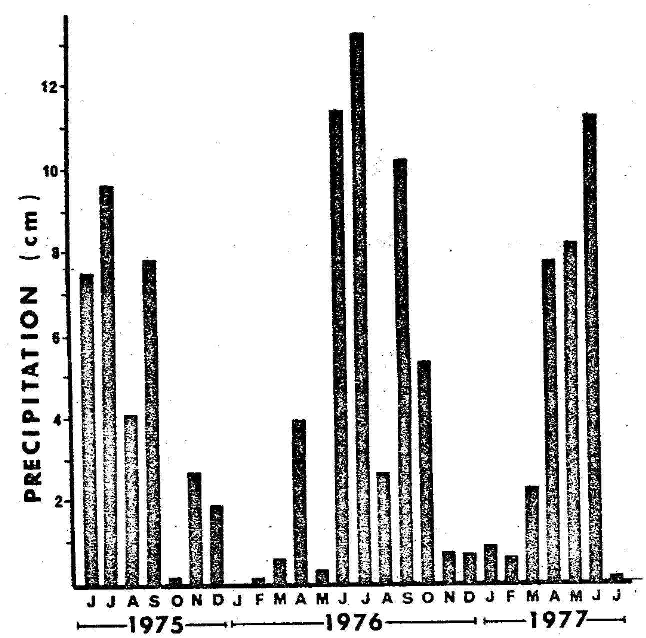

Fig. 1. *Precipitation (monthly totals) received on experimental plots from June, 1975, through July, 1977. Total precipitation for June, 1976, includes 8.46 cm applied to each plot by flood irrigation.*

Table 1. Cover repetition (mean number of hits/pin) for perennial grasses and broom snakeweed in October 1975 following various thinning treatments in July 1975.

Broom snakeweed density reduction (%)	Mean no. hits/pin	
	Perennial grasses	Broom snakeweed
0[2]	0.95 a[3]	0.61 b[3]
25	0.88 a	0.58 b
50	0.76 a	0.43 b
100	0.87 a	0.00 a

Initial mean density of broom snakeweed (387/m²) was reduced to 242/m² by October 20, 1975, by natural mortality in undisturbed plots.
Means within a column followed by similar lower case letters are not significantly different at $P<0.05$.

Biomass and Cover Repetition of Herbage

Reducing density of broom snakeweed plants had no effect on canopy cover repetition of perennial grasses at the end of the first growing season (October 1975, Table 1). Perennial grasses were in extremely low vigor when densities of broom snakeweed were reduced and did not respond immediately even though considerable precipitation was received during this period (Fig. 1). Statistically significant ($P<0.05$) reduction of cover repetition of broom snakeweed in October 1975 was achieved only by the complete removal treatment.

After 13 months (August 1976), standing crop of perennial grasses was significantly increased ($P<0.05$) only on plots where all broom snakeweed plants had been removed (Table 2; Fig. 2). Complete removal increased production of perennial grasses by 1,175 kg/ha (107%), whereas 25% and 50% density reduction did not affect perennial grass production (Table 2). Twenty-five or 50% reductions of broom snakeweed density did not significantly alter standing crop of this species compared to undisturbed plots, but broom snakeweed biomass was significantly ($P<0.05$) higher where density had been reduced by 25% as compared to 50% (Table 2). Reducing density of broom snakeweed did not reduce its biomass or increase perennial grass production proportionately. Reducing broom snakeweed density by 50% resulted in a 29% decrease in its biomass at 13 months after treatment. Decreasing broom snakeweed density by 25% appeared to have a stimulatory effect on its production, as evidenced by a 15% increase in standing crop (Table 2).

At 2 years after treatment, complete removal of broom snakeweed increased standing crop biomass of perennial grasses by 2,201 kg/ha (324%) (Table 2). Reducing broom snakeweed density by 25% or 50% had no significant ($P<0.05$) effect on perennial grass production compared to that in undisturbed plots. Broom snakeweed biomass was not significantly affected by reducing its density 25% or 50% (Table 2). Biomass of individual broom snakeweed plants increased as their density decreased within the density range encountered in this study. Broom snakeweed plants were more competitive with perennial grasses in the second year of their life cycle than in the first year, possibly due to extension and expansion of their root systems or to greater shading effect as their aboveground portions increased in size.

Table 2. Standing crop (kg/ha) of perennial grasses and broom snakeweed in August 1976 and in July 1977 following application of various thinning treatments in July 1975.

Broom snakeweed density reduction (%)	Standing crop (kg/ha)	
	Perennial grasses	Broom snakeweed
	August 1976	
0[2]	1094 a[3]	2377 bc
25	1094 a	2736 c
50	906 a	1686 b
100	2269 b	0 a
	July 1977	
0[4]	679 a	2473 bc
25	704 a	3084 c
50	1054 a	2200 b
100	2880 b	0 a

[2] Initial mean density of broom snakeweeds on undisturbed plots was 387/m², natural mortality had reduced mean density on undisturbed plots to 182/m² by May 20, 1976.
Means within a column, for the date indicated, followed by similar lower case letters are not significantly different at $P<0.05$.
[4] Population density of broom snakeweeds on control plots was approximately 180/m² in July 1977.

Complete removal of broom snakeweed increased perennial grass production by 1,175 kg/ha (1,048 lb/acre) in 1976 and by 2,201 kg/ha (1,964 lb/acre) in 1977. Assuming that only 25% of the total available herbage will be utilized by livestock (the remainder being consumed by insects and other herbivores, left standing dead, deposited as litter, lost due to trampling or contaminated with dung, etc.), and that an animal unit (A.U.) requires 12.02 kg (26.5 lb) of forage (dry weight) per day, complete control of broom snakeweed increased the estimated carrying capacity of this shortgrass rangeland in 1976 from 1 A.U./16 ha to A.U./7.7 ha and from A.U./26 ha to 1 A.U./6.1 ha in 1977.

Jameson (1966) reported that reducing broom snakeweed and Cooper actinea (*Hymenoxis cooperi*) standing crop by 90% and 60% with selective herbicides, respectively, increased blue grama production by 14 to 38% and also increased production of bottlebrush squirreltail [*Sitanion hystrix* (Nutt.) J.G. Smith] and forbs in a juniper-pinyon woodland in Arizona. Jameson reported that each kilogram of half-shrubs killed by herbicides was replaced by less than 0.5 kg of herbaceous plants. He speculated that larger responses of herbaceous plants to the treatments would have occurred if density of half-shrubs had been greater. In our study, each kilogram of broom snakeweed killed was replaced by 0.49 kg of perennial grass in 1976 and by 0.89 kg of perennial grass in 1977. Gesink et al. (1973) reported that perennial grass production was 300 to 600% greater on shortgrass rangeland in Wyoming where broom snakeweed had been controlled for 5 years with one application of various rates of picloram alone or in combination with 2,4-D, as compared to undisturbed rangeland.

Soil Water Depletion

In October 1975 (3 months after treatment), with complete removal of broom snakeweed, soil water depletion was significantly ($P<0.05$) decreased in the 15 to 30 and 30 to 45-cm increments as compared to undisturbed, 25%, and 50% density reductions (Table 3). Since perennial grasses had not responded to complete removal of broom snakeweed at this time, these data suggest that juvenile broom snakeweed plants were utilizing soil water from the 15 to 45-cm increment of the soil profile. Reducing broom snakeweed density by 25 to 50% did not affect soil water depletion as compared to undisturbed stands.

In January 1976, complete removal of broom snakeweed resulted in a significant decrease in soil water depletion in the 0 to 15-cm increment as compared to 25 to 50% density reduction, but none of the treatments were significantly different from the untreated plots (Table 3). Soil water depletion was significantly greater in the 15 to 30-cm increment where broom snakeweed density was reduced 25 or 100% compared to the

Table 3. Soil water (cm) at various times after treatment, by depths, and as affected by thinning or complete removal of broom snakeweed in July 1975[1].

Depth (cm)	Broom snakeweed density reduction (%) 0	25	50	100
	October 1975			
0–15	1.04 ab[2]	0.89 a	0.97 ab	1.14 b
15–30	1.23 a	1.23 a	1.23 a	1.60 b
30–45	1.51 a	1.52 a	1.44 a	1.71 b
45–60	1.50 a	1.49 a	1.45 a	1.46 a
60–75	1.44 a	1.46 a	1.41 a	1.43 a
75–90	1.50 a	1.47 a	1.48 a	1.51 a
90–105	1.64 a	1.54 a	1.55 a	1.70 a
105–120	1.71 a	1.50 a	1.67 a	1.63 a
	January 1976			
0–15	1.67 ab	1.37 a	1.48 a	1.82 b
15–30	2.05 b	1.59 a	1.81 ab	1.74 a
30–45	1.91 b	1.61 a	1.73 ab	1.75 ab
45–60	1.63 a	1.55a	1.58 a	1.62 a
60–75	1.56 a	1.51 a	1.48 a	1.54 a
75–90	1.55 a	1.54 a	1.51 a	1.57 a
90–105	1.73 a	1.73 a	1.71 a	1.64 a
105–120	1.62 a	1.73 a	1.82 a	1.76 a
	April 1976			
0–15	0.96 a	0.80 a	0.76 a	0.87 a
15–30	1.33 b	1.19 ab	1.05 a	1.18 ab
30–45	1.45 a	1.39 a	1.27 a	1.28 a
45–60	1.46 a	1.44 a	1.42 a	1.33 a
60–75	1.39 a	1.46 a	1.45 a	1.29 a
75–90	1.54 a	1.48 a	1.59 a	1.47 a
90–105	1.69 a	1.65 a	1.79 a	1.66 a
105–120	1.71 a	1.72 a	1.70 a	1.62 a
	August 1976			
0–15	0.75 a	0.72 a	0.68 a	0.66 a
15–30	0.97 b	0.90 ab	0.92 ab	0.77 a
30–45	1.26 a	1.14 a	1.19 a	1.17 a
5–60	1.26 b	1.22 b	1.16 ab	0.99 a
–75	1.33 b	1.30 b	1.25 ab	1.15 a
–90	1.34 a	1.38 a	1.33 a	1.25 a
90–105	1.51 a	1.57 a	1.50 a	1.48 a
105–120	1.51 a	1.55 a	1.56 a	1.51 a
	July 1977			
0–15	0.81 b	0.83 b	0.81 b	0.67 a
15–30	1.05 a	0.95 a	1.00 a	0.90 a
30–45	1.31 b	1.15 ab	1.25 b	1.03 a
45–60	1.30 b	1.23 b	1.29 b	1.01 a
60–75	1.33 b	1.27 b	1.32 b	1.10 a
75–90	1.40 b	1.38 b	1.36 b	1.18 a

[1] Mean population density of broom snakeweed on undisturbed plots was 387/m² in August 1975, 242/m² in October 1975 and 182/m² in May 1976.
[2] Means within a row followed by similar lower case letters are not significantly different at $P<0.05$.

undisturbed stands. Soil water depletion in the 30 to 45-cm increment was significantly increased by removing 25% of the broom snakeweeds.

In April 1976 (9 months after treatment), soil water depletion in the 15 to 30-cm increment was significantly ($P\leq0.05$) greater in the plots with one-half the normal density of snakeweeds than in the undisturbed plots (Table 3). There were no differences in soil water content at other depth increments.

In August 1976 (13 months after treatment), soil water depletion in the 15 to 30, 45 to 60 and 60 to 74-cm increments was significantly increased by complete removal of broom snakeweed ($P<0.05$) (Table 3). There was also a trend in all ··rements down to 75 cm for soil water depletion to increase as :eweed density decreased. By this time, perennial grasses .d responded to density reduction of broom snakeweed (although not linearly) and grass root systems had apparently begun to effectively utilize available water in the upper 75 cm of soil.

At 2 years after treatment, complete removal of broom snakeweed resulted in significant increases in soil water depletion in all increments down to 90 cm except the 15 to 30-cm increment (Table 3). Removal of 25 or 50% of the broom snakeweeds did not affect soil water depletion compared to that of the undisturbed plots. As at 1 year after treatment, perennial grasses had responded to elimination of interspecific competition with broom snakeweed. Root systems of blue grama, buffalograss, and sand dropseed [*Sporobolus cryptandrus* (Torr.) Gray] had apparently extended to greater depths and were effectively using soil water throughout most of the soil profile. Similar increases in soil water depletion following control of big sagebrush (*Artemisia tridentata* Nutt.) have been reported by Tabler (1968) and Sturges (1977).

All dates on which soil water was determined coincided with periods when most or all available soil water had been extracted by evapotranspiration. Total soil water content for the upper 120 cm was below the range generally considered available for plant growth for this soil, 28.7 cm at −⅓ bar and 15.2 cm at −15 bars, on all sampling dates. Only on January 13, 1976, were soil water levels for any of the depth increments within the range usually considered available. At that time, available water was present in the 0 to 15-cm and 15 to 30-cm depths, indicating some recharge from 0.73 cm of precipitation the preceding 60 days. At the October 9, 1975, sampling date, 18 days had passed without precipitation, and 8.9 cm had fallen in the preceding 60-day period. On the April 7, 1976, sampling date, no precipitation had been received in 30 days and only 0.6 cm in 60 days. Twelve days had passed without precipitation preceding the August 18, 1976, sampling but 23.6 cm had fallen within 60 days. Twenty-six days had passed without precipitation preceding the July 20, 1977 sampling, with 15.2 cm within 60 days. Thus, soil water is extracted to the wilting point from this soil very rapidly during summer and fall. Total precipitation during November through March periods of 1975-76 and 1976-77 was 5.2 cm and 5.1 cm, respectively; therefore, little or no recharge occurred during either winter period. Soil water loss through evaporation during the hot summer months is undoubtedly very high in the study area, and might be expected to mask any small differences in water withdrawal among the treatments studied. However, the consistent pattern, at 13 months and at 2 years after treatment, of increased soil water depletion from most depth increments on broom snakeweed-free plots compared to infested plots leaves little doubt that soil water extraction by vigorous shortgrasses is greater than by dense stands of broom snakeweed.

Precipitation and Forage Production

Adequate controls (i.e., complete removal of all vegetation

Table 4. Precipitation received (cm) and precipitation-use efficiency [forage produced (kg/ha)/cm precipitation received] of perennial grasses on broom snakeweed-infested and broom snakeweed-free shortgrass rangeland in west Texas during 1976 and 1977.

Year	Precipitation[1] (cm)	Forage (kg/ha) cm precipitation: Broom snakeweed infested rangeland	Broom snakeweed free rangeland
1976	46.14	23.7	49.2
1977	63.76	10.6	45.2

[1] Total precipitation received during preceding 12-month period.

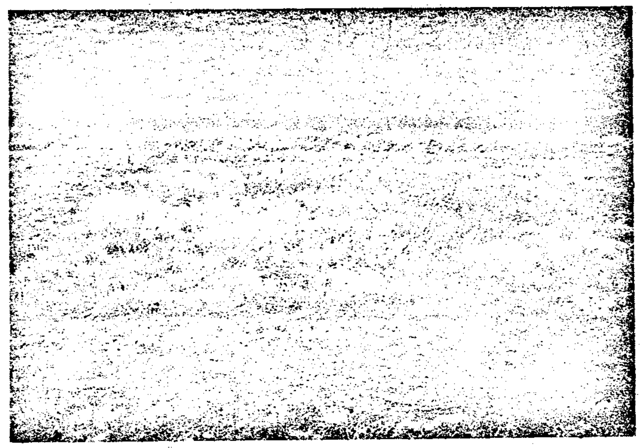

Fig. 2. *Broom snakeweed-infested plot (left) produced 1,094 kg/ha of perennial grass forage during the 1976 growing season while snakeweed-free plots (right) produced 2,269 kg/ha.*

and complete removal of all plant species except broom snakeweed) were not utilized in this study to facilitate evaluation of relative efficiencies of broom snakeweed or grasses in utilizing soil water. However, our precipitation records indicated that 46.14 cm of precipitation was received in the 12-month period prior to our 1976 clipping study and 63.76 cm were received in the 12-month period prior to our 1977 clipping study. In 1976, 23.7 kg of perennial grass herbage were produced per cm of precipitation received on snakeweed-infested plots as compared to 49.2 kg/cm on snakeweed-free plots (Table 4). In 1977, snakeweed-infested rangeland roduced 10.6 kg of herbage per cm of precipitation, compared to 45.2 kg/cm on snakeweed-free rangeland. Precipitation-use efficiency was increased 2.1 times in 1976 and 4.3 times in 1977 by removing broom snakeweed. Scifres et al. (1977) reported that about twice as much herbage was produced per cm of precipitation received on South Texas rangeland sprayed for brush control as on brush-infested range.

Summary and Conclusions

Broom snakeweeds, especially at high densities, are highly competitive with perennial grasses on shortgrass prairie rangelands. Control practices that are only partially effective may not result in increases in forage production where initial population density of broom snakeweed is very high. Broom snakeweeds appear to be more competitive with shortgrasses during the second year of their life cycle than in the first year. Perennial grasses did not respond quickly to control of snakeweed populations because their initial vigor was low, but herbage production increased by 107% and 324% at 1 and 2 years, respectively, after 100% removal of broom snakeweed. Reducing snakeweed density by 25 or 50% did not affect production of perennial grasses. Juvenile snakeweeds apparently use soil water mainly from the upper 15 to 45-cm increment of the soil profile. Complete removal of snakeweeds resulted in increased soil water depletion down to 90-cm after 2 years. Precipitation use efficiency for forage production increased 2.1 and 4.3 times at 1 and 2 years, respectively, following complete moval of broom snakeweed.

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